

INSULATED MATERIAL AND ARTICLES MADE THEREFROM

RELATED APPLICATION

This application claims priority of U.S. Provisional Patent Application Serial
No. 60/461,680 filed April 9, 2003, and entitled "Composite, Thermal Insulation
5 Material."

FIELD OF THE INVENTION

This invention relates generally to thermally and acoustically insulated
materials. More specifically, the invention relates to composite insulation materials.
Most specifically, the invention relates to lightweight, thermally and acoustically
10 insulated articles which are stable under high temperature conditions, and have utility
in the automotive, marine, recreational vehicle, aerospace and other industries, and to
methods for their manufacture.

BACKGROUND OF THE INVENTION

Thermal insulation is utilized in many locations in motor vehicles for the
15 purpose of controlling ambient temperature conditions and/or preventing thermal
damage to temperature-sensitive components. Such insulation is also employed to
absorb acoustic energy in many instances. In addition to restricting the flow of heat
and/or sound, such insulation should be thermally stable, light in weight, and it should
not occupy an unduly large volume. In addition, insulation employed in the
20 manufacture of motor vehicles and other high volume items should be low in cost.

In prior art vehicular applications, heat shielding is frequently accomplished by the use of rigid, fixed metal heat shields which are molded or welded in place around high temperature structures such as catalytic converters, mufflers, manifolds and the like. Metallic heat shields of this type are difficult to attach, bulky, and heavy. Furthermore, they are not effective in damping noise, and can actually be a source of vibration and hence contribute to overall vehicle noise. Furthermore, rigid heat shields are difficult to employ in connection with structures having complicated shapes such as tanks, fluid lines and the like.

The prior art has also employed liquid based foams or coatings, such as sprayed on, brushed on or dip coatings, as insulating materials. Coatings of this type are fairly expensive to employ; and while they can provide good acoustic insulation, they generally do not have high temperature resistance and are not effective as thermal insulation for high temperature applications. The prior art has also experimented with blanket type thermal and/or acoustic insulation for vehicular applications. Such blanket insulation is based upon a fibrous material typically with a backing material such as metal foil or the like. Blanket insulation material heretofore employed is limited in its applications because the fibrous materials utilized are not thermally stable under the broad range of operating temperatures encountered in vehicular applications. It will thus be appreciated that there is a need for a lightweight, flexible, low cost, easy to utilize insulation material having good thermal and acoustic absorption. Such material will have significant utility in connection with

motor vehicles including land vehicles, marine vehicles, and aerospace vehicles. In addition, materials of this type will have significant utility in buildings and other structures.

5 The present invention is directed to a thermal insulation material and methods for its use which have particular utility in the manufacture of motor vehicles such as automobiles, trucks, aircraft and spacecraft as well as in other industrial applications. The insulation material and methods may also be readily employed in other applications including appliances, tools, construction materials and the like. The insulation material of the present invention is highly efficient in absorbing thermal and acoustic energy, and hence occupies a relatively small volume. The insulation material is also very stable under high temperature conditions, and it is low in cost. Furthermore, the insulation material and methods of the present invention may be readily adapted for use with variously configured components by utilizing relatively simple technologies. These and other advantages of the present invention will be
10
15 apparent from the drawings, discussion and description which follow.

BRIEF DESCRIPTION OF THE INVENTION

A first aspect of the invention disclosed herein comprises a thermally and acoustically insulated vessel. The vessel is comprised of a body of polymeric material which defines at least a portion of the vessel, and a body of refractory fabric
20 which is partially embedded in, and retained by, the polymeric material so that a portion of the body of refractory fabric is exposed upon the surface of the body of

polymeric material. The exposed portion of the fabric provides thermal and acoustic insulation for the vessel. The fabric may comprise a non-woven fabric, and one specific fabric comprises carbonized filaments of a polymeric material such as polyacrylonitrile. In particular embodiments, the vessel comprises a duct such as a
5 duct of a heating, cooling and ventilation system. In such embodiments, the refractory fabric is disposed upon the interior, gaseous fluid conducting, surface of the duct. In other embodiments, the vessel comprises a tank such as a fuel tank, and the refractory fabric is disposed upon an exterior surface of the tank. In particular embodiments, the refractory fabric may have a layer of a metallic material disposed
10 thereatop. In yet other embodiments, the vessel may comprise a conduit such as a conduit for carrying electronic or fiber optic communication lines, and the refractory fabric may be disposed upon either or both of the interior and exterior surfaces of the conduit.

Disclosed herein is a method for manufacturing the insulated vessels of the
15 present invention. In accordance with the method, there is provided a mold for shaping a body of liquid polymeric material into the configuration of the vessel. The mold may comprise an injection mold, blow mold, slush mold, or the like. The body of fabric is disposed within the mold in contact with a shaping surface of the mold, and the polymeric material introduced thereinto. The polymeric material infiltrates a
20 portion of the thickness of the fabric, and when hardened, provides a polymeric member having the fabric bonded to a surface thereof.

In accord with another aspect of the present invention there is disclosed a thermal and/or acoustic insulating material comprised of a layer of refractory fabric and a layer of a metallic material disposed at a superposed relationship with a first surface of the layer of refractory fabric. The metallic material may comprise a metal
5 foil, such as a steel or aluminum foil; or, it may comprise a woven material such as a co-woven aluminum and glass fiber material. In further embodiments, a layer of reinforcement material, such as a layer glass fiber, may be interposed between the refractory fabric and the layer of metallic material. The insulation material may also include a layer of adhesive which allows the insulation material to be bonded to a
10 member which is to be insulated.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a cross-sectional view of a composite, insulating material structured in accord with the present invention;

Figure 2 is a cross-sectional view of another embodiment of a composite,
15 insulating material structured in accord with the present invention;

Figure 3 is a cross-sectional view of an insulated duct structured in accord with the present invention;

Figure 4 is a cross-sectional view of a portion of an insulated tank structured in accord with the present invention; and

20 Figure 5 is a cross-sectional view of a portion of another embodiment of an insulated tank structured in accord with the present invention.

DETAILED DESCRIPTION OF THE INVENTION

One aspect of the present invention comprises a composite thermal insulation material which includes a layer of refractory fabric utilized in conjunction with a layer of a metallic material, such as a woven metal fabric or metal foil. This combination of components provides a material which is a very efficient thermal insulator. The material of the present invention can also function as a sound absorbing material. It is very light in weight and very flexible, and can be supplied in sheet or roll form, and readily configured on site for various applications.

In particular embodiments, the insulation material of the present invention is adhesively affixable to another surface, as for example by means of a body of contact adhesive. As will be described in greater detail, the insulation material may include further components such as reinforcing layers and additional functional materials such as sound or vibration absorbing materials. These additional components may comprise one or more layers separate from the refractory fabric; or, they may be incorporated directly into the refractory fabric.

Referring now to Figure 1, there is shown a cross-sectional view of one embodiment of insulating material structured in accord with the principles of the present invention. The insulating material 10 of Figure 1 includes a layer of a refractory fabric 12. As will be understood within the context of this disclosure, a refractory fabric comprises a woven or non-woven textile material which is resistant to high temperature conditions, typically conditions in excess of 200°F, and

preferably in excess of 500°F. Refractory fabric will comprise a body of woven or non-woven fibrous material which may consist of mineral fibers, carbon fibers such as graphite or pyrolytic carbon, organic fibers having high temperature resistivity, and the like.

5 One particularly preferred refractory material is prepared by the pyrolysis of organic polymers, which yields a material comprised of pyrolytic carbon and/or oxidized polymer. A specific material of this type comprises a carbonaceous fabric prepared by the high temperature degradation of fibers of polyacrylonitrile. This material includes very large amounts of carbon together with some polymer residues.

10 The material is highly inert to oxidizing and reducing conditions. In addition it is light in weight and flexible, and is a highly effective thermal insulator. Materials of this type are available from Apex Technical Fabrics LLC. under the trademark Heatseal-X. Material of this type has a weight of approximately 10 ounces per square yard at a nominal thickness of one-quarter inch. It is stable to temperatures exceeding

15 1000°F. It is resistant to chemical attack, and is hydrophobic. The material is generally available as non-woven, felted and/or needled sheets. While this particular refractory fabric is one preferred material for the practice of the present invention, the invention is not limited thereto, and other refractory fabrics may be employed with equal advantage. In some instances, the refractory fabric may comprise a mixture of

20 the pyrolytic carbon fibers with another material. For example, polymeric reinforcing fibers such as aramid fibers may be blended with the carbon fibers to increase the

strength of the resultant fabric. Other fibers which may be included in the blend include, but are not limited to, high temperature polymers such as polysulfones, mineral fibers and the like. While the thickness and weight of the layer of refractory fabric will depend upon the specific application for the insulation material, typical
5 thicknesses will be in the range of 1-50 millimeters, and typical weights will range from 4-50 ounces per square yard.

The Figure 1 embodiment further includes a layer of metallic material 14 disposed in a superposed relationship with a first surface of the refractory fabric 12. In this particular embodiment, the layer of metallic material 14 is a woven material
10 comprising aluminum and glass fibers, and it is adhesively bonded to the first surface of the refractory fabric 12 by means of a layer of adhesive 16. While the layer of metallic material 14 is, in this embodiment, a co-woven fabric of aluminum and glass fibers, it is to be understood that other materials, including metal foils, woven materials, non-woven materials and the like may be employed. In this embodiment,
15 the metallic material is aluminum-based; however, it can be based upon other metals such as steel. While there is no inherent limitation on the thickness of the metallic material, as a practical matter, issues of flexibility, weight and cost will generally restrict preferred materials for use in the present invention to a thickness in the range of one mil to one-quarter of an inch.

20 The metallic material 14 is adhesively affixed to the refractory fabric 12 by means of a layer of adhesive 16. Typical adhesives for use in the present invention

comprise contact adhesive formulations, although hot-melt and thermosetting adhesives may also be employed. As is further shown in Figure 1, a layer of glass fiber fabric 18 is interposed between the metallic material 14 and refractory fabric 12. The glass fiber layer 18 is optional but has been found to enhance the tear resistance and strength of the composite. In some instances, the reinforcement layer may be dispensed with, while in other instances, materials other than the glass fiber may be employed. Such materials can include ceramics, high strength refractory polymers and the like.

In the Figure 1 embodiment, a layer of contact adhesive material 20 is disposed upon a second face of the layer of refractory fabric 12. This adhesive layer 20 is optional, but functions to allow the composite thermal insulation material 10 to be adhered to a support surface, such as a portion of a motor vehicle. Typical adhesives comprise contact adhesives of the type known in the art; although other adhesives such as solvent-based adhesives, thermosetting adhesives, hot-melts and the like may be likewise employed. In the Figure 1 embodiment, a layer of release material 22, such as a layer of silicone or polypropylene coated paper, is disposed atop the adhesive layer 20.

Yet other embodiments of the present invention may be implemented. Referring now to Figure 2, there is shown yet another composite, thermal insulation material 30 structured in accord with the principles of the present invention. In this embodiment, a layer of refractory fabric 12, generally similar to the layer described

with reference to Figure 1, has an aluminum foil layer 14 bonded thereto by a body of adhesive 16, as generally described hereinabove. This embodiment includes yet another fabric layer 24 affixed to the second face of the refractory layer 12. In this particular embodiment, the layer 24 is a layer of sound absorbing material, and the
5 composite unit 30 of Figure 2 functions as a thermal shield and sound absorbing material. The layer of sound absorbing material 24 may comprise a layer of woven or non-woven fabric, or it may comprise a body of polymeric material such as an elastomeric sponge or a solid body of material. The layer of refractory material 12 and the additional layer 24 may be affixed together by various means, depending
10 upon their respective compositions. In those instances where both comprise fabric layers, they may be joined by mechanical processes such as sewing, needling or the like. In other instances, the layers may be affixed by adhesives. The sound absorbing material may, in some instances be incorporated directly into the refractory fabric to produce a composite. In those instances where the refractory fabric is non-woven, the
15 two materials may be mixed. Where the fabric is woven, they may be co-woven. As in the previous embodiment, the composite thermal insulation material 30 of Figure 2 includes an adhesive layer 20, and a body of release material 22; although, it is to be understood that these members are optional.

Yet other embodiments of the present invention may be implemented. For
20 example, while the upper layer of the material is described herein as being a foil other layers may be similarly employed. For example, the upper layer may be comprised of

a metalized fabric such as a glass fabric or a metalized high temperature polymer. Also, still further layers of materials may be incorporated into the structures of the present invention. Likewise, attachment members such as brackets, braces or other hardware fixtures may be utilized to support the thermal insulation material of the present invention.

The material of the present invention is light in weight and very flexible, and is amenable to being cut or shaped by relatively simple processes such as die cutting, blade cutting, stamping or the like. The high degree of flexibility of this material allows it to be provided in a roll or stacked sheet form. Its flexibility allows it to readily conform to a variety of configurations which allows it to be employed as a thermal insulation material motor vehicles. Typical vehicular applications will include: the power train, the power train tunnel, the front dash panel, floor pans, and exhaust systems.

The present invention may be adapted, in another embodiment, to provide structures having integral thermal and/or acoustic insulation. Such structures can be advantageously employed as ducts, tanks, conduits, and the like for vehicles as well as static structures.

Referring now to Figure 3, there is shown a cross-sectional view of a portion of an air duct 40. Such ducts are employed in the heating and air conditioning systems of motor vehicles; although, it is to be understood that this invention may be similarly employed for other ducts. The climate control system of motor vehicles is a

significant source of noise. The ducts communicate with blowers, compressors, as well as the engine compartment and can operate to pipe noise into the motor vehicle. In accord with the present invention, such ducts can be provided with an insulating layer which dampens sound vibrations, and which provides additional thermal insulation. As shown in Figure 3, the duct 40 is comprised of a body of polymeric material 42 which defines the basic shape of the duct. This polymeric material 42 can be any of the high strength engineering plastics generally employed for the manufacture of items of this type. In accord with the present invention, a layer of a refractory fabric 44 is bonded to an inner surface of the duct 40. The refractory fabric is of the type generally described hereinabove, and carbon based refractory fabrics are one specific material which may be employed for this purpose. What is notable about the duct 40 of Figure 3 is that the refractory fabric 44 is partially embedded in the polymeric material 42 forming the duct so as to provide a permanent bond. This is most advantageously accomplished in the course of the molding procedure employed for the fabrication of the duct 40. Ducts of this type are often manufactured by injection molding; and in accord with the present invention, a body of refractory fabric 44 is disposed within a mold cavity, and a hardenable polymeric material, such as a molten thermoplastic or a thermosetting formulation, is introduced into the mold. The polymeric material infiltrates a portion of the thickness of the fabric 44, and upon hardening of the polymeric material, the fabric 44 is bonded thereto.

The presence of the high surface area fabric 44 on the interior surface of the duct serves to greatly decrease sound vibrations. The fabric 44 absorbs acoustic vibrations traveling through the body of the polymeric material 42 forming the duct thereby damping such vibrations. Furthermore, the surface of the fabric 44 attenuates sonic waves passing through the air stream contained within the duct. It has been found that the inclusion of the fabric 44 in even a portion of the ducting of a climate control system of a motor vehicle significantly decreases the interior noise level of the vehicle. It has been also found that the presence of the fabric 44 provides insulation to the duct 40 thereby increasing the overall heating and cooling efficiency of the system.

While the fabric layer 44 is shown as encircling the entirety of the interior circumference of the duct 40 in Figure 3, it is to be understood that the fabric need not line the entirety of the duct in order to be effective. Good noise reduction will be achieved with embodiments in which the fabric covers only a portion of the surface of the duct, either in the form of strips, discrete patches, or the like.

This aspect of the invention may be implemented in yet other embodiments. Referring now to Figure 4, there is shown a cross-sectional view of a portion of a tank such as a fuel tank for a motor vehicle. The tank 50 is, in this embodiment, fabricated from a body of polymeric material 52, which polymeric material is compatible with the structural requirements of the tank as well as the fluids intended to be contained therein. As in the previous embodiment, a body of refractory fabric 54 is partially

embedded in and retained by the polymeric material 52. However, in this embodiment, the fabric 54 is disposed upon the exterior surface of the tank, and primarily functions as a thermal insulation material. Inclusion of the thermal insulation material increases the overall safety factor of the tank 50. As in the
5 previous embodiment, the fabric 54 is bonded to the polymeric material 52 during the molding process. It is to be understood that the principles of the present invention may be implemented in connection with injection molding processes as well as other molding processes such as blow molding, extrusion molding, slush molding and the like. Also, the refractory fabric need not be bonded at the same time as the article is
10 being molded. Bonding may take place following the molding step by a thermal lamination process, melt bonding or the like.

Referring now to Figure 5, there is shown yet another embodiment of fuel tank 60 configured in accord with the present invention. The tank 60 of Figure 5 is generally similar to the tank 50 of Figure 4, and in that regard comprises a body of
15 polymeric material 52 defining the tank, and a body of refractory fabric 54 bonded thereto. However, the tank 60 of Figure 5 further includes a layer of a metallic material 62 affixed to the refractory fabric 54. This additional layer 62 may be in accord with the various metallic layers described hereinabove, and operates to provide still further thermal insulation.

20 Yet other embodiments of this aspect of the present invention may be implemented in accord with the teaching presented herein. For example, conduits,

such as the conduits used to carry wiring harnesses, fiber optic cables, communication cables and the like, in a variety of structures, may be provided with the insulating layer of the present invention. In such instance, conduit can be readily manufactured in a molding process, such as an extrusion process or the like, so as to have an
5 integral refractory fabric bonded thereto. Insulated conduit of this type will have a number of applications in vehicles as well as static structures for insulating communication lines, fluid delivery lines, fiber optic lines and the like.

In view of the foregoing, it is to be understood that yet other modifications and variations of the present invention may be implemented. Therefore, the
10 foregoing drawings, discussion and description are to be understood as being illustrative of specific embodiments of the present invention, and not as limitations upon the practice thereof. It is the following claims, including all equivalents, which define the scope of the invention.